Geologically Speaking

A Michigan Section AIPG Publication

Inside This Issue:

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Front Cover: Dead Pool Falls north of Marquette. The bedrock at the falls is the Precambrian aged Mona Schist. A glacial groove has been carved into the rock in front of the falls. Photo taken by Sara Pearson during the Minerals & Falling Water Field Trip at the Annual Meeting in August 2022.

Geology Crossword #9 Solution

P	L	E	I	S	T	O	C	E	N	E	■	■	■	■	E	■	■	■	W
A	■	■	C	■	■	■	I	■	■	■	L	O	E	S	S	■	■	■	I
T	■	■	E	■	■	■	R	■	■	■	O	■	■	■	K	A	M	E	S
E	■	■	■	■	■	■	Q	■	M	■	B	■	■	■	E	■	■	■	C
R	O	C	H	E	M	O	U	T	O	N	E	E	■	■	R	■	■	■	O
N	■	■	■	■	■	■	E	■	U	■	■	■	■	G	■	■	■	■	N
O	U	T	W	A	S	H	■	■	N	■	■	E	R	R	A	T	I	C	S
S	■	I	■	■	C	■	■	■	T	■	O	■	■	O	■	■	S	■	I
T	■	L	■	■	O	■	■	■	A	■	U	■	■	O	■	H	O	R	N
E	■	L	■	■	U	■	D	R	I	F	T	■	■	V	■	■	S	■	A
R	■	■	■	■	R	■	■	■	N	■	B	■	■	E	■	■	T	■	N
L	■	■	P	■	■	■	■	■	■	■	U	■	■	■	■	■	A	■	■
A	D	V	A	N	C	E	■	■	■	D	R	U	M	L	I	N	S	■	■
K	■	■	V	■	■	■	■	■	■	■	S	■	■	■	■	■	Y	E	■
E	■	■	E	■	■	L	A	C	U	S	T	R	I	N	E	■	■	U	■
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■	■	■	N	■	■	■	■	■	■	■	O	■	■	■	■	■	■	A	■
■	R	E	T	R	E	A	T	■	■	■	O	■	F	J	O	R	D	S	■
■	■	■	■	■	■	■	■	■	■	■	D	■	■	■	■	■	■	Y	■

Across
1. Lower Quaternary series
6. Windblown silt deposit
7. A low mound or ridge
9. Sloped bedrock knob, often polished
11. Sand and gravel plain
14. Unreliable, unpredictable
17. Musical instrument
18. To float with a current
20. To move forward
21. Not something you bang on
22. ___ of little faith
24. Formed in a lake
25. A cooking implement
26. Large sheet of ice
27. To fall back, rapidly
28. A flooded embayment

Down
1. Chain of small circular bedrock lakes
2. A solid less dense than its liquid form
3. Glacial source area
4. Sinuous surface feature, formed under ice
5. Latest glacial stage
6. Part of an ear
8. Not a molehill
10. Get into it
12. Farmers do this in the spring
13. To hand clean crusty dishes
15. Crustal rebound
16. A sudden release of meltwater
19. A smooth surface to drive on
23. Global changes in sea level

From the President's Desk

I can't believe that fall is right around the corner. Summer brought us some awesome AIPG events such as the AIPG Annual Workshop at the RAM Center and the AIPG National Meeting held in Marquette. We will be finishing off summer with the Annual AIPG Michigan Section Golf outing on September 13 and the AIPG/MAEP Joint Meeting on September 21. Our membership in Michigan is packed with lots of talented people who donate their time and energy to developing excellent opportunities for us to come together. I would like to take this time to recognize and thank all the volunteers for all the 2022 summer activities.

AIPG Annual Workshop:

- Sara Pearson
- Tammy Rabideau
- Bill Mitchell
- Poonam Rameshbabu
- Kalan Briggs
- Laura Lambert
- Adam Heft
- Rick Dunkin
- Wayne Amber

AIPG Annual Meeting:

- Adam Heft
- Amy Hoeksema
- Joe Swarz
- David Adler
- Al Blaske
- Mark Petrie
- Linda Hensel
- Kim Ethridge
- Mellisa Powers-Taylor
- Mark Sweatman
- Chris Christensen
- Richard Raetz
- Poonam Rameshbabu

AIPG Annual Golf Outing:

- Kalan Briggs
- Laura Lambert
- Dan Stone
- Duane Hattem
- Heather Smith
- Gail Carr
- Andy Foerg

AIPG/MAEP Joint Meeting:

- Kalan Briggs
- Jennifer Lagerbohm
- Laura Lambert
- Gail Carr
- Cheryl Ann Farmer

As we look ahead to the fall, I want to remind everyone of several more ways to step up and help our organization. Please consider running for Secretary this fall. Volunteering your time on the executive committee is an excellent way to help shape our organization into the future! I also strongly encourage our membership to nominate members for the various awards we present at the Annual Meeting at Weber's in December. This is a great way to honor those who have worked so hard for our organization and in the field of geology. Information on awards can be found here: https://mi.aipg.org/awards.htm

Enjoy the rest of the summer and I look forward to seeing you all at our September events!

Mellisa Powers-Taylor

Check Out the AIPG Mentoring Program

Mentoring is an experience that promotes personal growth, creates meaningful connections, and sparks creative innovations. AIPG offers an opportunity to connect mentees with mentors. To sign up for the program is easy and can be done when paying your annual dues or updating your online profile. You may check the box on your paper dues renewal form that you send in via mail or log into your account at www.aipg.org and update your member profile. Be sure to check whether you would like to be a mentor or mentee and the fields of expertise. The system allows individuals to search for people with similar interests and connect via email. Check it out today!

ENVIRONMENTAL, INC.

Established in 1992, AST has a 26 year track record of meeting our client's needs. AST has four office locations:

- Our Corporate Headquarters – Midway, Kentucky
- Regional Offices:
  - Springboro, Ohio
  - Harrisonburg, Virginia
  - Golden, Colorado

AST prides itself in being an innovative, technology driven organization that has a proven record of results. In fact, AST has a **90% closure rate** of project sites. Every time AST performs a project, our goal is to achieve the site-specific cleanup standards. AST owns and maintains over 35 pieces of heavy equipment (yellow iron) and specialty in-situ remediation and environmental sampling equipment to fulfill our client's entire project needs.

Our primary goal is to provide cost-effective environmental services for a wide spectrum of projects including: soil and groundwater remediation, landfill and cap construction, demolition, and underground storage tank removal. AST's comprehensive experience allows an understanding of the critical need for environmentally sound and economically feasible services that are compliant with local, state, and federal regulations.

AST is also proud to be affiliated with Remediation Products, Inc. (RPI). RPI is dedicated to quality control and achieving site closures by utilizing **Safe, Effective**, and **Predictable** processes. RPI's business model is different than what you will find with other in-situ remediation product manufacturers. Primary distribution and sales of the Trap & Treat® products is handled by a highly-trained international network of RPI Group Members including AST Environmental, Inc., **the National Product Distributor and Approved Installer Trainer.**

Annual Meeting Post Mortem

The AIPG Michigan Section hosted the 2022 Annual Meeting in Marquette on August 6-9, 2022. For those who have never been to an Annual Meeting, there was a lot to take in and be part of. From field trips, which any geologist loves, to the technical sessions, welcome reception and silent auction, there was something for everyone! And of course, the business meetings of the National Executive Committee, Advisory Board, and Foundation of AIPG took place on Saturday, August 6th. All members are welcome to attend the business meetings. There was even an entire day (opposite the business meetings) dedicated to students and early career professionals.

The meeting was based at the Northern Center of Northern Michigan University. Less than five years old, the facility was spectacular and well able to accommodate our meeting activities. The food was also very well done, and I have heard no complaints in that regard.

This year, as the meeting Chairman, I mandated that no field trips would occur the same day as the technical sessions to give the presenters maximum exposure. Past meetings have had relatively dismal turnout and participation in the technical sessions because they were competing with great field trips. Not this time! Several of the sessions had packed rooms and featured very interesting presentations on a variety of subjects.

Field trips (there were six of them) were run on Sunday and Tuesday. All were well attended, and thoroughly enjoyed by all participants. Half of the trips allowed opportunities for collecting samples, including for the limited number of participants to obtain samples of the high-grade nickel-copper sulfide ore from the Eagle Mine! There were also a number of samples collected from the Champion Iron Mine tailings piles; at least one individual found a nice hand sample containing molybdenum.

The silent auction, held Sunday evening at the welcome reception was intended to raise money for the Foundation. We were fortunate to have several generous donors who contributed a total of 54 items for the auction. The evenings proceedings were at times heated, and bidding on a few items were like a tennis match between two or three individuals, each of whom were determined to take home a nice item. Overall, the auction raised almost $3,800 for the Foundation.

As meeting Chairman, I would like to sincerely thank the following individuals for their work in helping plan the various aspects of the Annual Meeting:

- Field Trip Chairman Allan Blaske, and assistant planners Dave Adler and Mark Petrie.
- Technical Session Chair Mellisa Powers-Taylor
- Student Events Chair Amy Hoeksema, and assistant planner Joe Swarz
- Sponsor/Exhibitor Chair Linda Hensel
- Abstract Reviewers Mark Sweatman, Richard Raetz, and Poonam Rameshbabu
- Local Planner Kim Ethridge

Next year's Annual Meeting is AIPG's 60th, and will be held in Covington, Kentucky, across the river from Cincinnati, Ohio. This meeting is also within convenient driving distance for most of our members, and I hope you will consider participating and helping keep AIPG a relevant part of our profession. Look for information about the meeting in the AIPG eNews emails and in the Apr/May/Jun edition of TPG. I hope to see you there!

Per-and polyfluoroalkyl substances (PFAS) are extremely mobile in water, leading to widespread contamination. Long-term use of PFAS chemicals have resulted in contamination of land, groundwater and surface water resources which can threaten water supplies.

AECOM PFAS SOLUTIONS

- Worked on over 500 PFAS sites globally
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- Full-scale PFAS design, construction, and operation for drinking water supplies using both GAC and IX technologies
- Leachate and industrial effluent treatment
- Wastewater facility studies on PFAS fate through treatment plants, advanced reuse facilities and biosolids land application sites
- DE-FLUORO™ PFAS Destruction technology destroys 90-100% of total PFAS mass in majority of samples treated
- Continuous Innovation – on-site soil and groundwater bench, rapid small-scale column testing, pilot scale testing
- Worldwide experience in PFAS investigation, risk assessment and treatment
- Conducted largest PFAS investigation ever performed with 15,000 samples, investigating 80 mile segment of river

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Did You Know?

This article is intended to remind members of various aspects of AIPG and benefits of membership. If there is something you would like to see featured in this column, please contact the Editor…

Content for this issue's content was obtained from page 217 of the publication "A History of AIPG, 1963—2003. Information was modified to bring the information up to date.

AIPG has seen declining membership for over two decades. We had 4,589 CPGs on the roster in 2001 but only 2,997 this year. This is a 35 percent reduction in CPGs. Why is this happening? There are a few primary reasons, including the fact that our membership is aging and many CPGs are retiring. As of 2004, 20 percent of all CPGs were between 66 and 96 years old.

Secondly, many geologists don't see the value of being a CPG because of state registration.

Back at AIPG's inception, the original mission was to attest to the competency of professional geologists through certification and act as an advocate for the profession. Our 2003 National President, Rick Powers (CPG-06765), felt strongly the membership trend needed to be reversed. He felt that we must focus our attention towards advocacy of our profession and member services while encouraging AIPG certification. Estimates at that time were that there were approximately 120,000 practicing geologists in the United States.

There were two issues that most members had likely heard from non-members, including:

- "I have to fill out that application and wait six or more months to become a CPG."
- "Why should I join AIPG? I'm already a registered geologist."

Suggested answers were:

- "No, you don't have to become a CPG. We want

you to join the Institute as a member and help us to promote the profession and the ethical practice of geology. All you need to do is fill out a card, attest that you are a degreed geologist and will abide by AIPG's Bylaws and Code of Ethics. I'll be your member sponsor. In the future if you want to add the CPG credential to your resume you can apply later."

- "Are you concerned with your profession? If so, you should join with the other several thousand geologists that believe strongly in the profession of geology and its ethical practice."

AIPG offers many opportunities for continuing education that are relevant to our profession. Being a member of AIPG often means the cost for the continuing education opportunities are lower than for nonmembers. And by being an active participant in AIPG activities, you will often learn about upcoming activities (technical presentations, webinars, field trips, and more) before others will.

Participation in AIPG activities also leads to many networking opportunities, both here in Michigan, and across the country. Many of our members are decision makers for their company, and will often give extra consideration to a fellow AIPG member, particularly if that individual is known to them. You've heard the adage "It's not *what* you know, it's *who* you know." That certainly applies with AIPG members.

These issues and responses are still relevant today. AIPG needs you to promote membership to your professional friends and colleagues. Feel free to use these talking points when talking to someone about AIPG. I hope you encourage someone to join AIPG today!

Coming Events

September 13, 2022: Michigan Section AIPG 18th Annual Golf Outing. Fox Hills—Golden Fox Golf Course. Registration information at: https://www.eventregisterpro.com/event/americaninstituteofprofessionalgeologists.

September 21, 2022: Joint Michigan Section AIPG/MAEP meeting. An Effective, Step-wise Approach for Evaluating the Volatilization to Indoor Air Pathway (VIAP), by Jay Eichberger, Erica Bays, and Kalan Briggs. The meeting will be held at Waldenwoods Conference Center in Howell. Additional details can be found in the flyer in this edition of *Geologically Speaking*.

September 30 - October 2, 2022: AIPG MN/WI Geology and Remediation Weekend. Emerging contaminants and PFAS will be primary topics. Participants will also be offered field trip options to Bluff Natural Areas or Karst Areas, and a cruise on the Mississippi River to the #7 dam.

September 30 - October 2, 2022: AIPG IL/IN Field Trip to the St. Francois Mountains. All AIPG Members are welcome. RSVP by September 16, 2022 to anna.sutton@stantec.com.

October 12-13, 2022: 2022 Source Water Protection Conference, Mt. Pleasant, Michigan. Abstract submittal deadline is May 28, 2022 at: https://egle.idloom.events/2022-Source-Water-Protection-Conference.

November

December 1, 2022: Michigan Section AIPG Annual Meeting. Speaker and Topic TBA. Meeting to be held at Weber's Inn, Ann Arbor.

December 5-7, 2022: Great Lakes PFAS Virtual Conference.

Minerals for Sale!

Long-time Michigan mineral collector and dealer, Bill Micols, is selling his lifetime collection of material. Bill is in Milford. For additional details, please see the full-page flyer on the following page.

SALE

50 year life time collection

Private museum with thousands of specimens;

MINERALS, FOSSILS, ARTIFACTS, CARVINGS, JEWELRY, ASIAN ANTIQUES, ETC.

From the collections of William J. Micol, Milford, MI… Can be contacted at 1-248-842-1705 APPOINTMENT ONLY
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Where in Michigan?

The April 2022 edition of *Geologically Speaking* featured a photograph of the Middle Devonian aged St. Anthony's Rock in St. Ignace. The formation is a sea stack, approximately 350 to 400 million years old. The photograph was correctly identified by Stephen Zayko.

This edition of *Geologically Speaking* features a new photograph **at right** - not the photo on the cover page. The first person to correctly identify what the photograph depicts (feature name, location, formation, and age) will win AIPG swag! Submit your entry via email to the editor; only one per person per issue please.

Don't forget to check out the feature article "Geology in Michigan" in this issue (as well as the last several editions) that presents a geologic feature of interest as a mini field guide. One of the best parts about being a geologist is field trips, and we are hoping that in your travels around the state or country you include these featured spots as a stop. Why not incorporate them into a family vacation or bring friends who may not be geologists and share these locations that make Michigan unique? We hope you enjoy reading about it, and more importantly, go see it in person! We invite you to share unique geologic features that you know about and submit a "mini field guide" to share with our members in future editions.

Invitation to Our Members!

Do you have a case study to share?

The Michigan Section AIPG promotes knowledge sharing and would like to feature case studies from projects where others may benefit from successes as well as lessons learned. We feel as professionals that learning from each other is a great opportunity that AIPG offers our members. AIPG offers connection with other professionals and their experiences in the work we do every day. This case study represents what we would like to offer more to our members, not only as a way to solve problems, but unify us as professional geologists. Additionally, do you have a suggestion for other types of information to share that would be of interest to our membership?

Please send your case studies and suggestions for future publication in upcoming editions of *Geologically Speaking* to the Editor.

Update Your Information!

Please be sure that you continue to receive the Section's *Geologically Speaking* publication and other announcements. Submit an updated e-mail address to Adam Heft at adam.heft@wsp.com. If you move or change places of employment, don't forget to send your new contact information to both the Section and to National. If you are not receiving announcements directly from the Editor, it is because your email address is not up to date with the Michigan Section.

Please help the Editor by making sure that your email address doesn't bounce when the next announcement is sent. And be sure to cc Dorothy Combs, National AIPG Membership Director at aipg@aipg.org when you update your contact information. Thank you!

Student Chapter News

Editor's Note: The following information was excerpted from the 2022 CMU Annual Report...

Programs to recruit new members

Each Fall, the Earth and Atmospheric Science Department hosts a Geology Majors/Minors Night. We present at this event to encourage new geology majors/minors to join AIPG. Additionally, we participated in CMU Fire Up Fridays, which are held in the Spring during prospective CMU student tours. During this event, we were able to talk with new students about what AIPG is and the activities our student chapter is involved in.

Activities with the CMU Earth and Atmospheric Science Department

In the Fall, many of our members participated in the Geology/Environmental Science Career Day and heard from CMU alumni about their careers. The department also brought in multiple guest speakers for short seminars throughout the year that multiple members attended. As a service to the department, particularly the intro-level geology classes, our student chapter hosts tutoring once a night each week, which our members volunteer their time for. Finally, our student chapter helped with the department's annual food drive. This is run as a student-faculty competition, with donations going to the CMU Student Food Pantry and local Isabella County Soup Kitchen. We work with the two other student groups in the department, the Student Chapter of the American Meteorological Society (SCAMS) and the Community of Future Environmental Scientists (CFES). This year, students beat the staff and the total donations (by weight) reached a new record high!

Activities within the community

This Spring, we reached out to the local Science Olympiad organizers for our region. A few of our members volunteered to help write the tests given for Dynamic Planet and Rocks and Minerals. Additionally, we were asked by a teacher from a local school if we would like to help her 6th grade class with testing physical and chemical properties of the Chippewa River at a local park. Three of our members were available and enjoyed getting to work with the students! We hope to continue engaging in more community outreach like this as pandemic-related protocols lift and allow us to interact more with the community in person.

Student food donations during the department food drive.

CMU AIPG members (from left to right images) Smitty, Teagan, and Emily help guide 6th graders as they learn about the Chippewa River.

CMU Department of Earth & Atmospheric Sciences Celebrates its "BIFtieth" Anniversary!

CALLING ALL CMU ALMUNI!

The Department of Earth and Atmospheric Sciences (formerly the Geology Department) is celebrating 50 years of Geology at Central Michigan University!

Alumni are invited to attend a "BIFtieth" Anniversary celebration on the CMU campus on October 7, 2022. Activities include an open house, time capsule, and bar-b-que.

A full events schedule and registration can be found at https://dar.cmich.edu/alumni/events/alumni/248 or scan the QR code. You can also order a commemorative, special-edition Geology BIFtieth long-sleve t-shirt designed by the CMU AIPG Student Chapter.

Arkansas and the Geologic Disconnect

Western Michigan University's AIPG Student Chapter embarked on a week-long expedition to the Ouachita Mountains and Hot Springs National Park (NP) in Hot Springs, Arkansas. Coming all the way from Kalamazoo, MI, the group was able to observe a wide range of geologic landscapes. Our journey started on Pleistocene glacial deposits, transitioned into karst terrain in Southern Indiana, Illinois, and Kentucky. And concluded with heavily folded, fractured, and hydrologically active sandstone, shale, chert and novaculite that were originally deposited in the deep ocean environments of the Carboniferous Period.

Along the way, we stopped at several locations like McCormick's Creek State Park, IN, where we traversed through a partially submerged cave system (Image One). Next, we stayed at Cave-in-Rock State Park, IL, where we observed beautifully preserved fossils in Limestone

Image 1: Ashley Patti, Will Roosien, Mary Howe, Lila Rode, Alexa Hempel, and Avianna Jackson explore a partially submerged cave system at Indiana's McCormick's Creek State Park. Photo by Tom Howe.

Image 2: Carbonate cliffs of Cave-in-Rock State Park in Illinois overlooking the Ohio River. Photo by Brandon Tulban.

Students - Reminder

Don't Forget: Each Student Chapter must submit two articles for publication in *Geologically Speaking* each year to qualify for Section funding. Send the articles to Adam Heft at adam.heft@wsp.com.

WANTED!

Your Articles for *The Professional Geologist*

- Technical
- Opinion
- Peer-Reviewed
- Michigan Geology

Please submit your draft article to the Editor, Adam Heft at: adam.heft@wsp.com. Technical requirements may be found on the AIPG website.

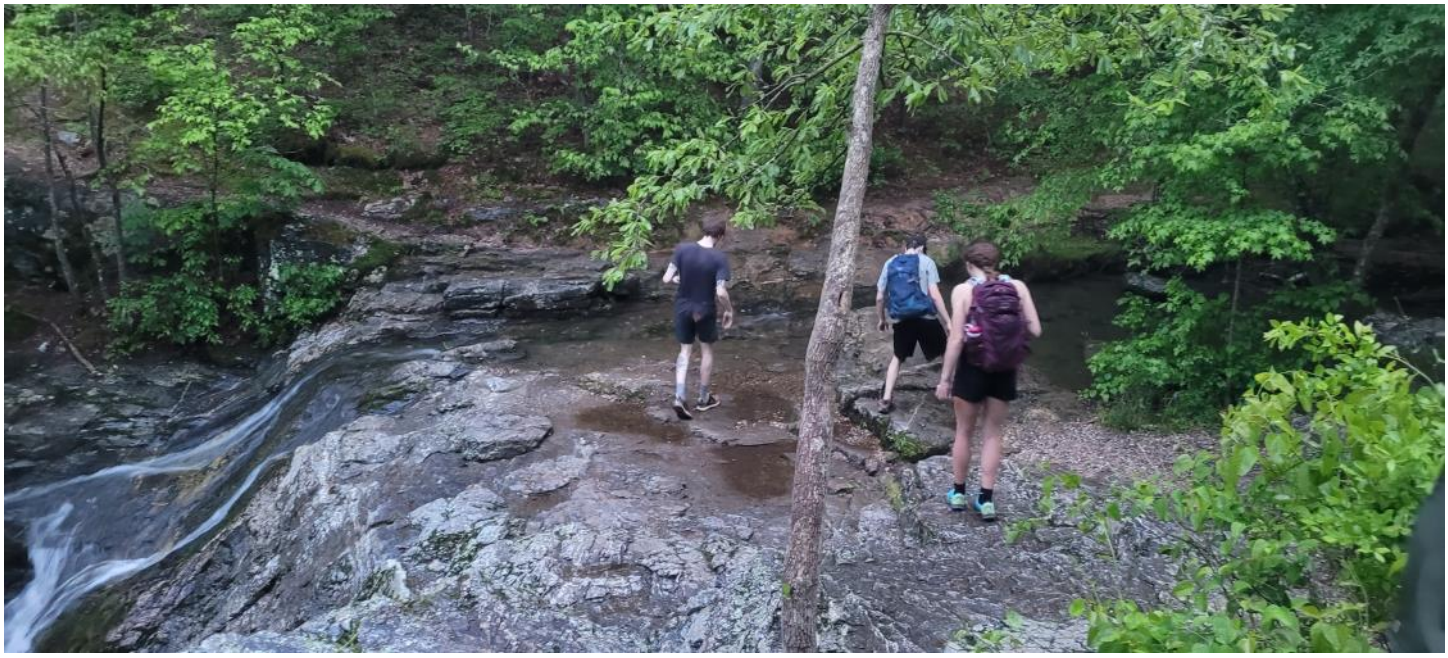

Image 3: Garrett Link, Donovan Vitale, and Alexa Hempel enjoy a beautiful hike at Catherine Lake State Park in Arkansas. Photo by Ariel Martin.

bluffs and the park's primary feature which is a 55-foot (17 m)-wide riverside cave formed by wind, water erosion and the cataclysmic effects of the 1811–12 New Madrid earthquakes (Image Two). The next morning, we crossed over the Ohio River via car ferry and then proceeded to drive all the way to Lake Catherine State Park, AR, where we dodged severe storms and went on beautiful hikes along powerful waterfalls (Image Three). We even got to go mining for quartz in Mt. Ida, Arkansas' World-Famous Wegner Phantom Mine, a real highlight of the trip (Image Four)! And of course, who could forget about Hot Springs National Park! The Park was a beautiful place where urban development met nature. Hot Springs NP is the second smallest national park in the US, but is also one of the most visited! It was fascinating to see how a whole town was able to develop and thrive from the areas' spring water (Image Five).

Image 4: Tom Howe, Matthew Carlson, and Ashley Patti explore Wegner Crystal Mines and look for elusive phantom crystals. Photo by Mary Howe.

Image 5: WMU AIPG Student Chapter at Hot Spring National Park with park Natural Resource Manager Nathan Charlton. Photo by Katie Dvorak.

For me, the most memorable and impactful part of the

trip occurred when we were able to observe a recently completed road-cut through the recharge zone of Hot Springs NP (Image Six). The most important resource within Hot Springs National Park is its spring water, which penetrates deep into the earth via highly fractured, porous, sedimentary rock. The recharge zone within the area that we explored recharges water into the spring system. As the precipitation percolates down into the earth, it is then heated by surrounding rock. In Hot Springs NP, this process takes approximately 4,000 years! In Image Six, we see how shale within the recharge zone serves as a basal confining layer directing the flow. A break in this conduit results in a decrease of water recharging to the Hot Springs aquifer. Unfortunately, a disconnect in the confining unit was created during the new highway excavation.

Although the new highway is already mostly completed, it is yet to be opened and the project has currently been put on hold while the entities work together to come up with a solution for reconnecting the recharge catchment. Meanwhile, having the opportunity to explore this road-cut on a completely traffic-free highway was a once in a lifetime opportunity provided to us by our friends and alumni there. To me, this dilemma was captivating. Issues like this are not black and white and blame cannot ever be placed on any one sole entity. Furthermore, what has happened represents the importance of communication and shows what can happen as a result of progressive urbanization in important sensitive areas such as national parks.

Image 6: Garret Link, Katie Dvorak, Will Roosien, and Ashley Patti observe a disconnect in the recharge zone of Hot Springs National Park. Photo by Ariel Martin.

The new highway was constructed as a means to connect the intersection of U.S. Highway 70 and East Grand Avenue with the intersection of State Highways 5 and 7. It's easy to look at an image like this and want to place the blame on the entities involved in the planning and completion of the road cut. In reality, the story is much more convoluted. The National Environmental Policy Act (NEPA) process of permitting the new highway was initiated in 2003. This process required lengthy studies to assess the hydrologic effect of highway construction on nearby wells. Ultimately, this study found that the construction would result in no major impact on surrounding wells. With this study complete, it was believed that the highway construction would have no negative effect to the National Park system or the surrounding residents. Unfortunately, during the highway construction, part of the excavation and blasting cut through the Park's recharge zone.

Section Website Reminders

The Michigan Section has created a database of geologic photographs on our website. Please submit photographs that you are willing to share to Adam Heft at adam.heft@wsp.com. Don't forget to include your name and a short explanation of what the photograph depicts. The photographs will be uploaded to the website periodically.

If you have suggestions on other items that should be included on the History page, please let a member of the Section Executive Committee know.

Thanks to the Annual Meeting Exhibitors!*

DeWind One Pass Trenching

Fibertec Environmental Services

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Geoscience World

Geostabilization International

Michigan Geological Survey

Vadose Remediation LLC

***These Companies do not have ads included elsewhere in *Geologically Speaking*.**

Regulatory Roundup

It has been a busy year so far! The state budget was passed early this year and per- and polyfluoroalkyl substances (PFAS) and drinking water remain at the top of the headlines.

With the passage of the budget, the Michigan Geological Survey, for the first time in a long time, has funding to hire staff for mapping and related projects. The budget also provides funding for the programs administered by the EGLE divisions. The bill analysis provides more details.

In June, the United States Environmental Protection Agency (US EPA) issued interim drinking water health advisories for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) as part of the PFAS Strategic Roadmap initiative. The new levels replace those set in 2016 by the EPA. According to the latest science and looking at exposure over a lifetime, the advisory levels are now near zero in drinking water. The advisories are 0.004 parts per trillion for PFOA and 0.02 ppt for PFOS. Additionally, EPA issued two final health advisories for hexafluoropropylene oxide (HFPO) dimer acid and its ammonium salt (together referred to as "GenX chemicals") and perfluorobutane sulfonic acid and its related compound potassium perfluorobutane sulfonate (together referred to as "PFBS"). The final lifetime health advisory for GenX Chemicals is 10 ppt and the final value for PFBS is, 2,000 ppt. More information on the calculation of the health advisories and EPA's PFAS roadmap can be found here.

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has also established new Water Quality Values for for PFBS PFOA. The source of the article dated July 27, 2022 below is from EGLE's website. An excerpt is below. The website includes a frequently asked questions section on this topic.

EGLE establishes new surface water values for two PFAS chemicals

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has established a new Water Quality Value (WQV) for perfluorobutane sulfonic acid (PFBS) and has revised the existing WQV for perfluorooctanoic acid (PFOA). PFOA and PFBS are members of the larger group of per- and polyfluoroalkyl substances (PFAS). WQVs are designed to protect the designated uses of Michigan's surface waters, including protections for aquatic life and public health.

The agency's Water Resources Division (WRD) determined that sufficient data was available to generate human health and aquatic life values for PFBS. Following the risk assessment method provided in Rule 323.1057 ("Rule 57"), a PFBS concentration of 670,000 parts per trillion (ppt; or nanograms per liter) was set for surface water to be broadly protective of human health and 8,300 ppt for surface water specifically protected as a drinking water source. While aquatic life values were established, the human health values are lower and thereby provide a more conservative endpoint with the overall goal of protecting water quality.

For PFOA, an update to the existing WQV from 2011 was undertaken after a review of current science indicated that a revision was needed to ensure the public and environment are protected from adverse effects. The revised human health values for PFOA are 170 ppt for surface water (reduced from 12,000 ppt previously) and 66 ppt for surface water protected as a drinking water source (reduced from 420 ppt, previously).

EGLE's WQVs for PFOS are not being updated at this time. EGLE continues to collaborate with other state departments and review new literature to determine if changes to its PFOS WQVs are warranted.

The Rule 57 Water Quality Values for Select PFAS (listed in nanograms per liter which is equivalent to parts per trillion) are as follows:

PFAS	HNV*(drinking)	HNV* (nondrinking)	FCV*	AMV*	FAV*
PFOS	11	12	140,000	780,000	1,600,000
PFOA[1]	66	170	880,000	7,700,000	15,000,000
PFBS[2]	8,300	670,000	24,000,0000	120,000,000	240,000,000

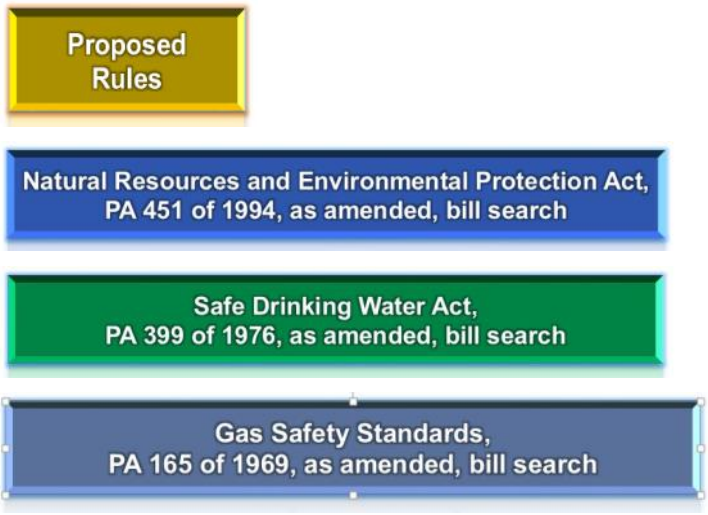
[1] Revised Values; [2] New Values

*Human Noncancer Value (HNV), Final Chronic Value (FCV), Aquatic Maximum Value (AMV), Final Acute Value (FAV)

In the last edition of the Regulatory Roundup, it was reported that Senate Bill SB 991 had been introduced on March 24, 2022 to amend Part 211 of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended. The bill revised placement distance of underground storage tanks from a public water supply system. The bill was signed by Governor Whitmer and took immediate effect on July 19, 2022 as PA 160 of 2022. This legislation only applies to replacement of existing USTs being installed in the same location. Construction of UST systems at new gas stations are required to meet the minimum isolation distances for major sources of contamination from existing drinking water wells. If the minimum distances cannot be met, a request for a variance must be requested from the Underground Storage Tank Division in the Bureau of Fire Services under the Department of Licensing and Regulatory Affairs (LARA). Hydrogeological information is needed for the variance requests to determine whether there is adequate natural geological protection to prevent contaminants from affecting the water quality if a release were to occur.

EGLE's Air Quality Division has a pending rule set #2022-18 EQ on the Part 6. Emission Limitations and Prohibitions – Existing Sources of VIC Emissions. If you are interested in this rule set, be sure to subscribe to the EGLE calendar for dates on upcoming public hearing and comment opportunities.

As always, we encourage you as an expert on these topics to lend your professional knowledge and experience and contact your legislators on any bills and rules that have been introduced. For additional searches on topics, the links are provided in the buttons below.



Member's Corner

The Member's Corner includes information about the Section's membership. This is your chance to provide information on where you are and what you are doing. Simply send the information to the Editor for inclusion in this section.

No submittals for this edition of the Member's Corner were received by the Editor in time for publication.

Interesting Geology Links

The Editor has received links to various interesting geology-related sites. Some of the more interesting links are included here. If you have any links to geology-related sites that you would like to share, please forward them (with a citation, if applicable) to the Editor.

Thanks to Mark Francek of Central Michigan University for sharing via the "Earth Science Site of the Week" emails. This edition features a few "fun" links.

This is a glacial lake outburst flood: https://atlas.eia.gov/apps/5039a1a01ec34b6bbf0ab4fd57da5eb4/explore.

Tornado at the base of La Palma Volcano: https://www.youtube.com/watch?v=7OJi7HE7TSI.

Japan's Okinawa Coastlines Struggling With Pumice Stones From Volcanic Eruption: https://https://www.usgs.gov/media/images/overview-water-quality-principal-aquifers-0.

Geology in Michigan –
The Champion Mine, Champion, Michigan

By Adam W. Heft, CPG-10265

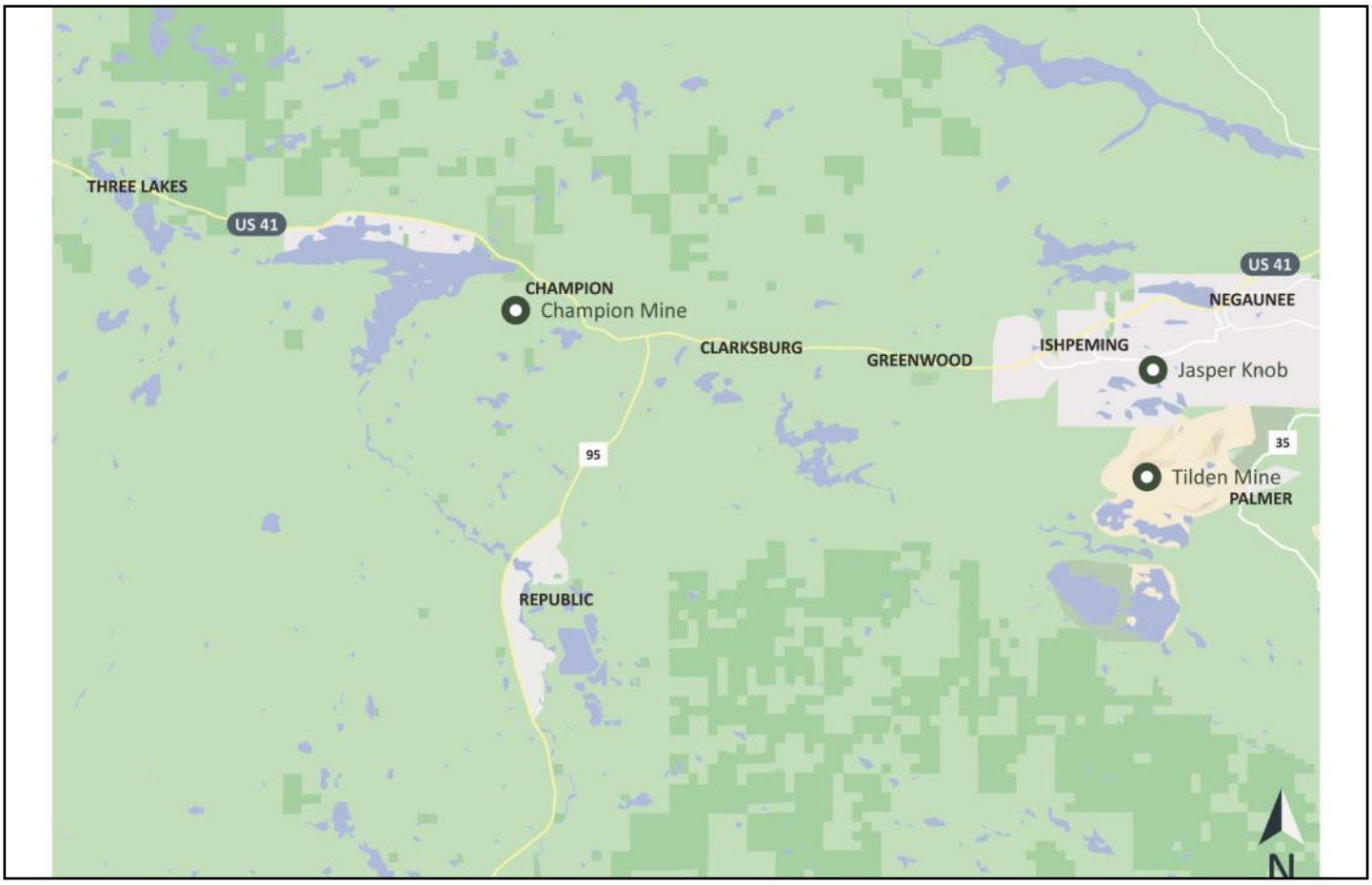


Figure 1: Source: https//snazzymaps.com/style/104137/default-w-out-labels.

Editor's Note: Information in this article was borrowed from the 2022 Annual Meeting Field Trip: Minerals & Falling Water and the 2018 Michigan Section Hard Rock & Heavy Metal Field Trip with citations.

Directions

The Champion mine is located west-southwest of the town of Champion, in Section 31 of T48N, R29W, in Michigan's Upper Peninsula. (Figure 1).

Latitude 46° 30' 29.23" N; **Longitude** 87° 59' 15.25"W.

From Marquette, take U.S. Highway 41 (US-41) west to Champion, about 26 miles. Turn left (southwest) on Main Street, which becomes County Road AAO after 0.2 miles, and continue for about 0.8 miles. Turn left onto Mine Street and proceed approximately 0.2 miles to the mine dumps and park.

Warning

The Champion Mine property is extensive, and is visited by people on a regular basis. There are, however, areas of the property that should be avoided—particularly those areas which are fenced. Caving or unstable ground is a possibility around the former shaft locations. Also, the author had at one point many years ago observed a concrete slab which likely covered one of the former mine shafts to have an area where the ground around one corner had eroded and a void was present. While it may

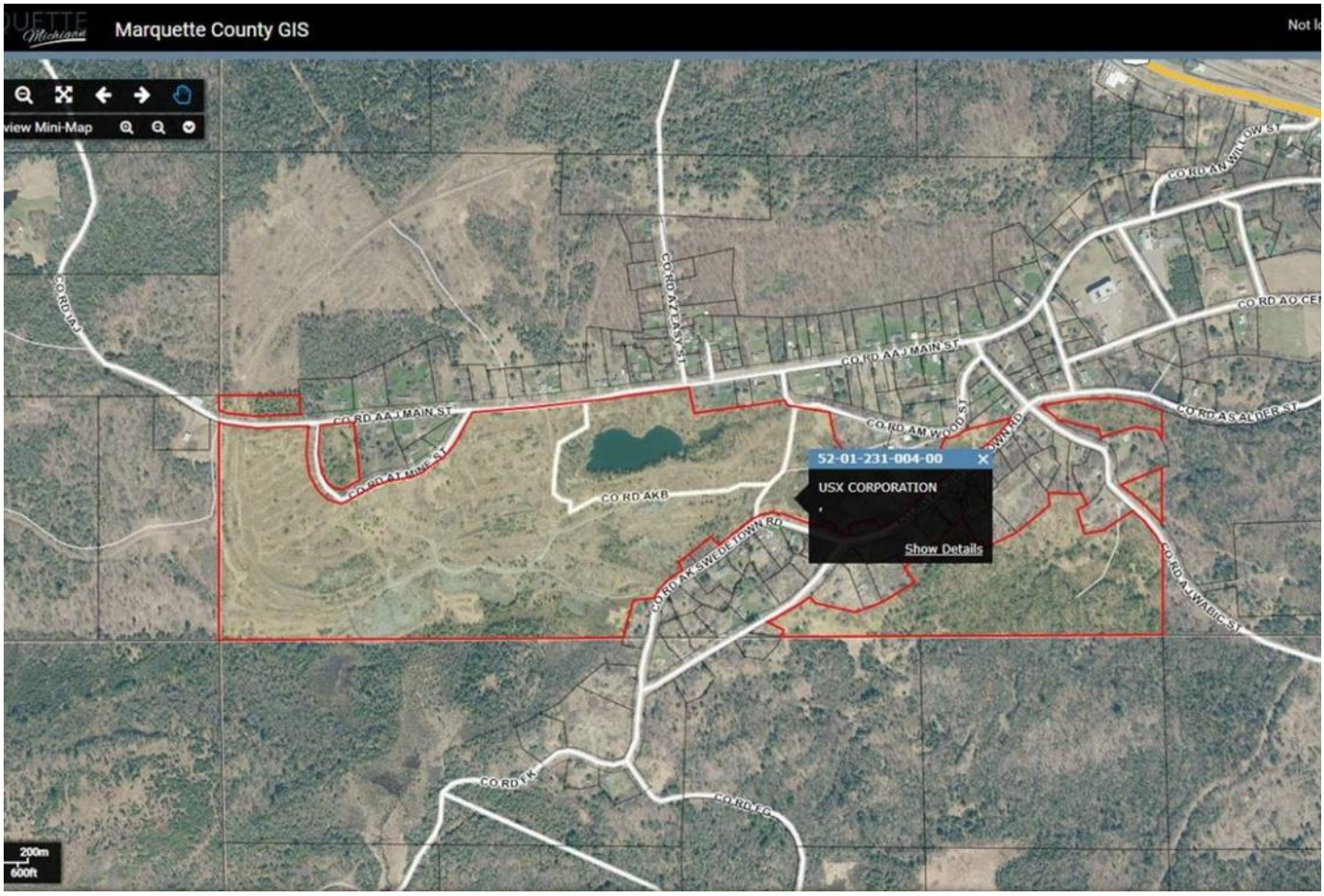


Figure 2: The Champion Mine property. The water body visible to the left of the text box is the location of the flooded mine shafts. Source: Marquette County GIS Department.

have been possible to slide under the slab, the dangers of doing so are numerous. The potential for dangerous atmosphere/lack of oxygen, the likelihood that once beneath the slab that a long vertical drop ending in water awaits the unwary, and the inability to get back out are only a couple of very real possibilities. The open pits around three of the original shafts (discussed below) have unstable ground and/or cliffs around them and falling could result in injuries. Care should also be exercised when climbing the tailings piles as rock may shift resulting in injuries if it falls on someone or shifts against a leg or foot. There have been reports of locals using parts of the property as a firing range. If this occurs during your visit, you may want to leave and come back another time so as not to catch a stray bullet or ricochet. Finally, be sure where you are so that you don't inadvertently trespass on one of the adjacent properties.

Introduction

The Champion mine is a primarily underground mine located within the southern limb of the Marquette trough and penetrates over 2,000 feet into the Negaunee Iron Formation, which was the formation hosting the ore at this and other locations in the area. The Champion Mine operated during the years 1867-1910 and 1949-1967 and produced a total of 7,012,911 tons of iron ore. In 1870, portions of ore around three of the seven shafts were removed as an open pit, which has since filled with water. This area is visible on an aerial view of the property shown on Figure 2.

Geologic Setting

The ore body was generally lens-shaped, and primarily consisted of the hard variety, primarily magnetite interbedded with iron-rich slate. The ore at this location has a

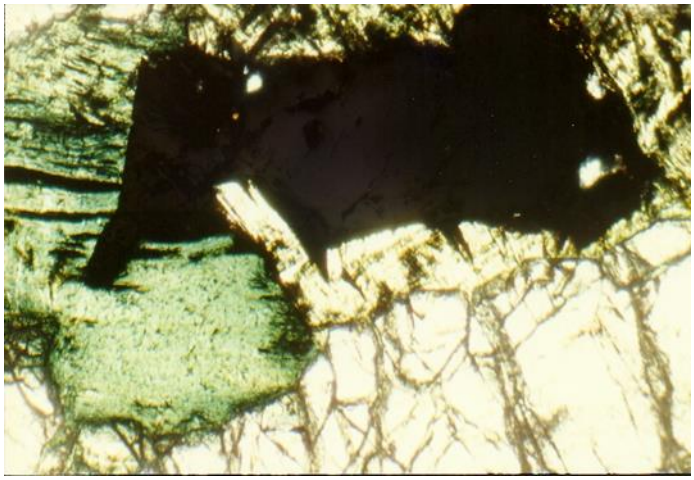


Figure 3: Photomicrograph of Garnet, Chloratoid, and Pyrite in Plane Polarized Light, Source: Heft, 1990 Undergraduate Thesis.

strike of N80°E, and dips approximately 70°NW. The con-

MARQUETTE MINERAL DISTRICT

MARQUETTE, BARAGA and IRON COUNTIES, MICHIGAN
GEOLOGIC COLUMN OF THE MARQUETTE MINERAL DISTRICT

COMPILED FROM PUBLICATIONS OF U.S. GEOLOGIC SURVEY,
MICHIGAN DEPARTMENT OF NATURAL RESOURCES - GEOLOGY DIVISION,
MICHIGAN TECHNOLOGICAL UNIVERSITY AND
UNPUBLISHED WORK BY CLEVELAND-CLIFFS IRON COMPANY
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CENOZOIC	PLEISTOCENE			GLACIAL DEPOSITS	
PALEOZOIC	ORDOVICIAN CAMBRIAN			G g	LIMESTONE & SANDSTONE
PROTEROZOIC	MARQUETTE RANGE SUPER GROUP	KEWEE-NAWAN		Yj	JACOBSVILLE SANDSTONE
				Yd	DIABASE - DIKES AND PLUGS LOCALLY ALTERED 1.1 Ga.
				Xhg	HUMBOLDT GRANITE - ALKALAI FELDSPAR GRANITE 1.75 Ga.
				Xmd	METADIABASE - METAMORPHOSED, MASSIVE TO SCHISTOSE
			EQUIVALENT TO U. MENOMINEE & L. BARAGA GROUPS	Xfl	STRATA NEAR FENCE LAKE - ARGILLITE, QUARTZITE, CONG., MAGNETITE I-FM
				Xfr	FENCE RIVER FORMATION - MAGNETITE - I-FM SILICATE IRON FORMATION
				Xh	HEMLOCK FORMATION - BASALT FLOWS AND FELSIC PYROCLASTICS 2.0 Ga.
		BARAGA GROUP	MICHIGAMME FM. UNDIVIDED Xmo	Xmb	BIJIKI IRON FORMATIONS - CHERTY SILICATE FE - FORMATIONS
				Xmu	UPPER SLATE MEMBER - METAGRAYWACKE, SCHIST, BLACK SLATE
				Xmi	IRON FORMATION - CHERTY SILICATE FE FORMATION
				Xmc	CLARKSBURG VOLCANICS - BASALTIC TO ANDESITIC PYROCLASTICS
				Xmg	GREENWOOD IRON FORMATION - MAGNETITE I-FM SILICATE I-FM
				Xml	LOWER SLATE - BLACK SLATE, IMPURE QUARTZITE, ARGILLITE
				Xg	GOODRICH QUARTZITE - QUARTZITE, CONGLOMERATES, ARGILLITE
		MENOMINEE GROUP		Xn	NEGAUNEE IRON FORMATION - CARBONATE, SILICATE & OXIDE IRON FORMATION
				Xs	SIAMO SLATE - ARGILLITE, SLATE, GRAYWACKE, GOOSE LAKE IRON MEMBER (Xsg)
				Xa	AJIBIK QUARTZITE - QUARTZITE, LOCAL CONGLOMERATE BEDS
		CHOCOLAY GROUP		Xcu	UPPER SLATES - SLATE, SCHIST, QUARTZITE & GRAYWACKE
				Xw	WEWE SLATE - GRAY SERICITIC and QUARTZ-SERICITE SLATE
				Xk	KONA DOLOMITE - VARIOUS COLORED MASSIVE DOLOMITE & CHERTY DOLOMITE
				Xm	MESNARD QUARTZITE - VITREOUS WHITE QUARTZITE GRAYWACKE INCLUDED
				Xel	ENCHANTMENT LAKE - INCLUDING REANY CREEK FORMATION ?
				Xtg	TILDEN GRANITE - 2.35 Ga.
	ARCHEAN	NORTHERN COMPLEX 2.6 - 2.7 Ga.		Wdrp	DEAD RIVER PLUTON - GRANO DIORITE AND SYENITE
				Ws	SERPENTINIZED PERIDOTITE
				Wrt	RHYOLITE TUFF - SCHISTOSE QUARTZ EYE TUFF
				Wnc	NEALY CREEK - METASEDIMENTS, WITH THIN IRON FORMATIONS
				Wk	DACITE VOLCANICS - TUFF BRECCIAS, TUFFS, FLOWS
				Wm	PILLOW BASALTS - MAFIC FLOWS, INTERFLOW SEDIMENTS, MINOR DACITE TUFFS
				Wa	AMPHIBOLITE - MASSIVE & FOLIATED AMPHIBOLITE
				Wgg	NORTHERN COMPLEX GRANITE
				Wgf	NORTHERN COMPLEX GNEISS - TONALITE & QUARTZ MONZONITE GNEISS
				Wp	PALMER GNEISS - CHLORITE PHYLLITE, QUARTZITE, IRON FORMATION
		Southern Complex 2.8-3.2 Ga.		Wgs	SOUTHERN COMPLEX GNEISS - FOLIATED TONALITE & COARSE GRAINED MICROPERTHITE
				Wgm	SOUTHERN COMPLEX MIGMATITIC GNEISS

Figure 4: Geologic Column of the Marquette District. Source: as indicated above, and as included in the Hard Rock & Heavy Metal Field Trip Guide, 2018.

Figure 5: The Champion Mine property ca 1897. Source: Photo from the Mining History Association website, https://www.mininghistoryassociation.org/MineralCollecting.htm.

tact between the rocks of the Marquette trough and the Southern Complex was only about 400 feet south of the mine. A metamorphosed diorite (now a talc-tremolite schist) formed the border with the rocks of the Marquette trough.

The Negaunee Iron Formation lies stratigraphically between the Ajibik Quartzite and the Goodrich Quartzite. The portion of the Negaunee Iron Formation in which the Champion Mine is situated is regionally located within the

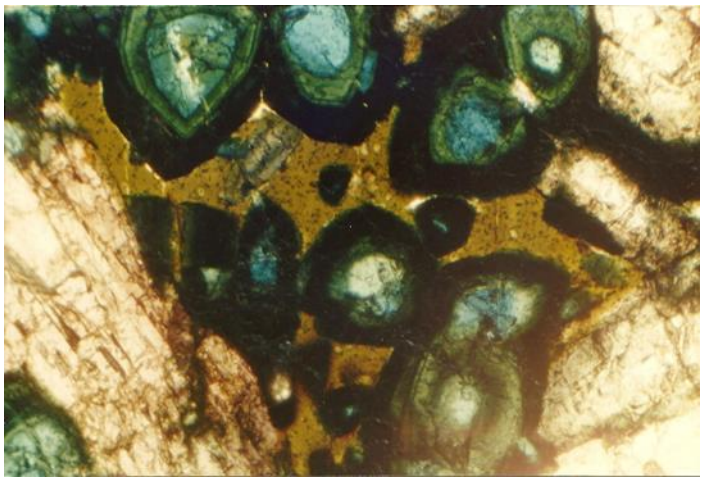

Figure 6: Photomicrograph of Zoned Tourmalines, Garnet, and Chloratoid in Crossed Polarized Light. Source: Heft, 1990 Undergraduate Thesis.

Republic node of metamorphism. This metamorphic node is roughly bullseye-shaped, extends outward nearly to Ishpeming, and covers approximately 2,700 square miles; the center of the node reaches sillimanite grade. Champion is within the staurolite zone of metamorphism of this

Figure 7: One of the tailings piles at the Champion Mine. Source: Adam Heft photo, 2018.

Figure 8: Specular hematite collected at the Champion Mine in October 2021, Photo by David Adler, CPG.

node. The source of the metamorphic node is believed to be a large batholith intruded into the area in the late Pre-cambrian.

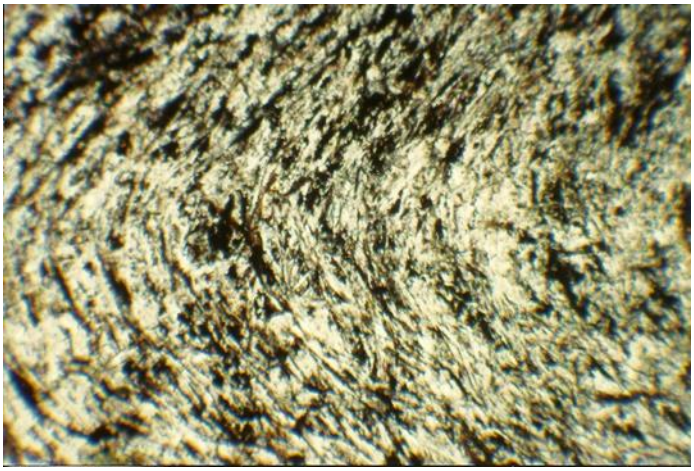

Figure 9: Photomicrograph Showing Microfold of Magnetite in Quartz in Plane Polarized Light. Source: Heft, 1990 Undergraduate Thesis.

Early researchers suggest that the iron formation was originally deposited as an iron rich carbonate sediment. The carbonate sediment was subsequently folded during the Penokean orogeny that formed the Marquette trough. Slumping of the carbonate during this process thickened the deposit, and the compression related to the Penokean orogeny produced fractures.

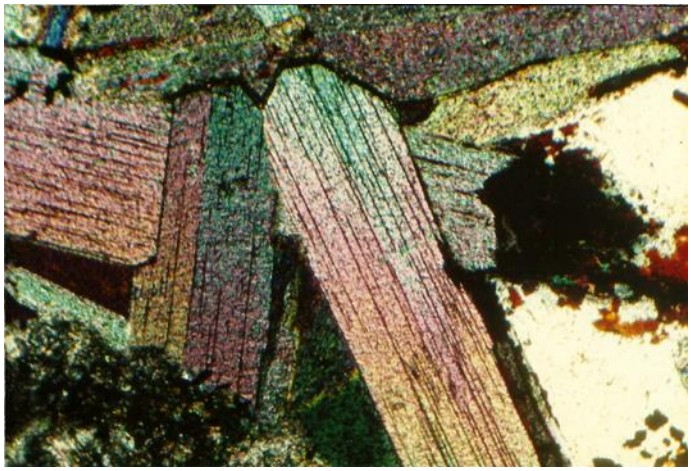

Figure 10: Photomicrograph of Muscovite, Ruby Muscovite, and Quartz in Plane Polarized Light. Source: Heft, 1990 Undergraduate Thesis.

There have been igneous intrusions into the

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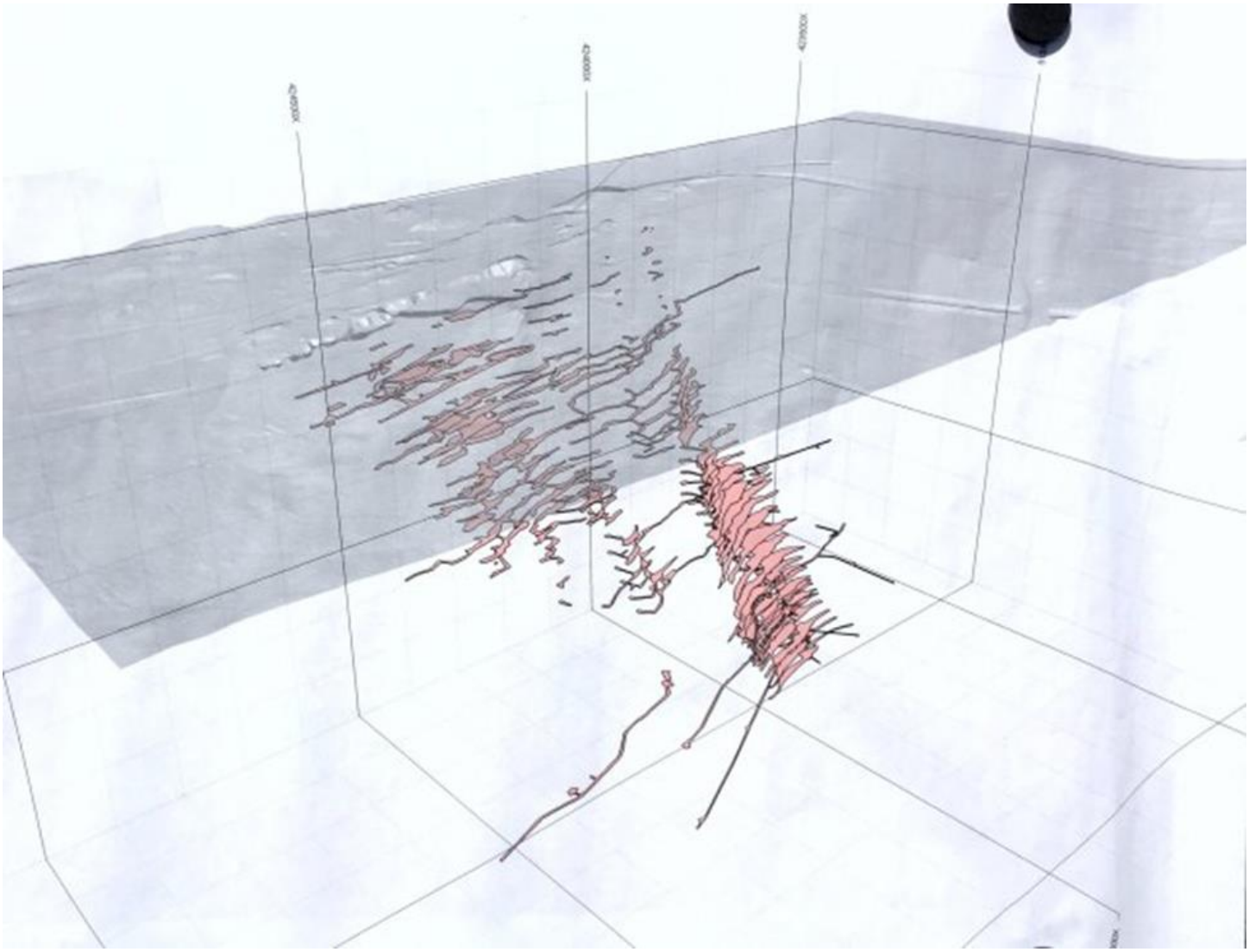


Figure 11: Underground workings of the Champion Mine. Photo from the Mining History Association website, https://www.mininghistoryassociation.org/MineralCollecting.htm .

Negaunee Iron Formation in the area; these intrusions manifest as pegmatites and hydrothermal veins. Pegmatites often have rare or valuable minerals associated with them, including molybdenite, pyrite, chalcopyrite, and gold. All these minerals have been reported at Champion. A total of 75 different minerals have been identified at Champion. Table 1 below lists all of the minerals known to have been found at Champion.

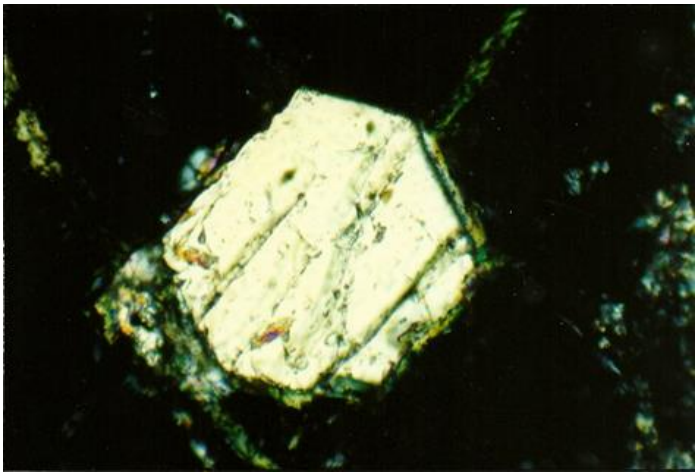


Figure 9: Photomicrograph showing apatite crystal. Source: Heft, 1990 Undergraduate Thesis.

Some of the easiest minerals to identify include hematite, magnetite, quartz, pyrite, chalcopyrite, siderite, biotite, muscovite, almandine garnet, staurolite, apatite, tourmaline (schorl), and molybdenite. Some of these minerals are rare and difficult to find. Some minerals, particularly tourmaline, have been found to be optically zoned (Figure 6).

Table 1: List of Minerals Found at Champion

Native Elements

Gold

Oxides

Hematite

Specularite

Martite

Magnetite

- Jacobsite
- Goethite
- Lepidochrosite
- Limonite
- Ilmenite
- Rutile

Sulfides

- Pyrite
- Marcasite
- Pyrrhotite
- Chalcopyrite
- Bornite
- Bismuthinite
- Molybdenite

Sulfates

- Anhydrite
- Gypsum
- Selenite
- Barite

Phosphates

- Apatite
- Monzonite

Carbonates

- Calcite
- Manganocalcite
- Siderite
- Manganosiderite
- Oligonite
- Rhodochrosite
- Fe-Rhodochrosite
- Dolomite
- Mn-Dolomite
- Fe-Dolomite
- Kutnahorite
- Ankerite
- Ca-Ankerite
- Malachite

Silicates

- Quartz
- Talc
- Fe-Talc
- Staurolite
- Schorl
- Dravite
- Orthoclase
- Adularia
- Albite
- Schefferite
- Rhodonite
- Hornblende
- Fe-Cummingtonite
- Mn-Cummingtonite
- Grunerite
- Actinolite
- Tremolite
- Almandine
- Spessartine
- Garnet solid solution
- Andalusite
- Viridine
- Kyanite
- Muscovite
- Sericite
- Biotite
- Chlorite
- Chloritoid
- Thuringite
- Clinochlore
- Prochlorite
- Aphrosiderite
- Sphene

Fluorides

- Fluorite

Halides

- Halite
- Sylvite

Tungstates

- Scheelite

Support our Sponsors!

The Section Executive Committee would like to remind its members to support the companies advertising in this publication. Consider working with these companies, and when you speak with their representatives, let them know that you saw their ad in the Michigan Section AIPG publication *Geologically Speaking*.

I Want To Publish Your Articles!

Hey everyone, I would like to encourage you to submit your articles for publication! As the Michigan Section Editor, and also the 2021-24 National Editor, I am working to put together two top-quality publications for our members. This is not a one person job. This is where you come in. I welcome your technical articles, case studies, opinion pieces, mini field guides, and letters to the Editor.

The guidelines are pretty simple for articles for *Geologically Speaking*. All submissions must be professional and may not violate the AIPG code of ethics. They also may not have been submitted for publication elsewhere. While most submissions will be accepted, we do not accept articles that are a sales pitch for a product or company.

The deadline for submitting articles for *TPG* is two months before the start of the quarter for which the *TPG* edition is published. Thus, February 1 is the deadline for the Apr/May/Jun edition.

Please submit your articles of no more than 3,200 words in MS Word format directly to me or to Dorothy Combs at National Headquarters at aipg@aipg.org. All graphics (photos, figures, or tables) should be submitted in .jpg, .tiff or other standard format at 300 dpi. Please ensure your graphics are clean and easy to read to make things easier for the editorial staff. Complete information on submitting an article may be found on National's website at: https://aipg.org/page/TPGInformation.

Michigan Section Golf!

Greetings everyone! The term "better late than never" surely applies this year! After an extra-long wait, I am pleased to announce that this year's golf outing is scheduled and will be held on **September 13th at the beautiful Fox Hills club** and will feature their championship **Golden Fox course in Canton, Michigan**! The Michigan Section is deep in the planning phases for our 18th Annual AIPG Golf Outing. Please spread the word to your suppliers and fellow colleagues, and plan to bring your A-game, drivers, polished irons, and fancy putters (or just be willing to play 18 holes and have a good time). The rolling picturesque landscape and rolling topography paired with an excellence in design and construction will make the engagement suitable for the stiffest of competition and cozy enough for us humans to just enjoy.

Please also consider a sponsorship this year as we really could not have this event without all of our new and perineal sponsors. There are several different levels of sponsorship listed on the event page and event flier. These sponsorship opportunities offer great exposure to some of the most influential professionals in our industry. Sponsors are also requested to include with their sponsorship a gift basket of at least $30 in value that will be raffled off with the rest of the prizes. Last year we raised approximately $450 from the gift baskets alone and we are ready to beat that amount with an even better event this year!

All money raised is put toward the Michigan Section's **K-12 Educational Grant** recipients. To ensure continued success, please join us by participating, sponsoring, soliciting sponsors, and/or donating prizes or items. Volunteers are also highly encouraged and very welcome!

This event is a great opportunity to spend time with colleagues and celebrate the closing end of a busy "summer field work" season here in the our beautiful state of Michigan. It is open to everybody, so please come and take advantage of the opportunity that so many others have done in the past. You need not be an avid golfer to participate.

The registration is now open and can be completed at the event website here: https://www.eventregisterpro.com/event/americaninstituteofprofessionalgeologists. If necessary, a hard copy registration form, along with a check covering the registration costs, can also be submitted to kalan briggs @ briggsk2@michigan.gov or mailed to 630 Piper Road, Haslett, MI 48840.

We hope to see you on September 13, 2022 !

Kalan Briggs, Golf Outing Chairman

Welcome New Members!

The Michigan Section is continuing to grow. Please welcome the following new CPGs, Professional Members, Early Career Professionals, Associate Members, and Students:

Matthew Bell, SA-11477; Dillon Breen, SA-11511; Heather Bricker, SA-11408; Maureen Casaus, SA-11493; Christopher Claes, CPG-12138; Trisha Cox, EXP-0949; Wiley Davenport, MEM-3416; Eric Dorais, SA-11496; Quin Doud, SA-11467; Maximillian Ehinger, SA-11410; Davis Eyth, ECP-0939; Hunter Golat, ECP-0914; Cole Keyworth, SA-11470; John Myaard, SA-11519; Zachary McFaul, ECP-0934; Andrea Munoz-Hernandez, MEM-3394; Daniel Nida, CPG-12131; Spencer Nuzum, SA-11471; Lars Olaussen, MEM-3399; Sananda Ray, SA-11516; Will Roosien, SA-11409; Lauren Schraeder, MEM-3377; Madison Schrader, SA-11469; Trenton Singer, MEM-3413; Anton Smirnov, SA-11492; Madeleine Tan, SA-11475; Amy Towell, ECP-0935; Luke Vermeulen, MEM-3372.

To each of our new members, welcome to our Section! We encourage you to attend Section meetings and other events. You are also invited to provide information for the Member's Corner articles.

ASBOG Exam Update

Ten individuals registered to take the ASBOG Fundamentals of Geology (FG) examination at Central Michigan University on October 7, 2022. This is the last time that the ASBOG exam will be given using a paper and pencil format. Beginning in March, 2023, the ASBOG will utilize a computer based testing (CBT) system.

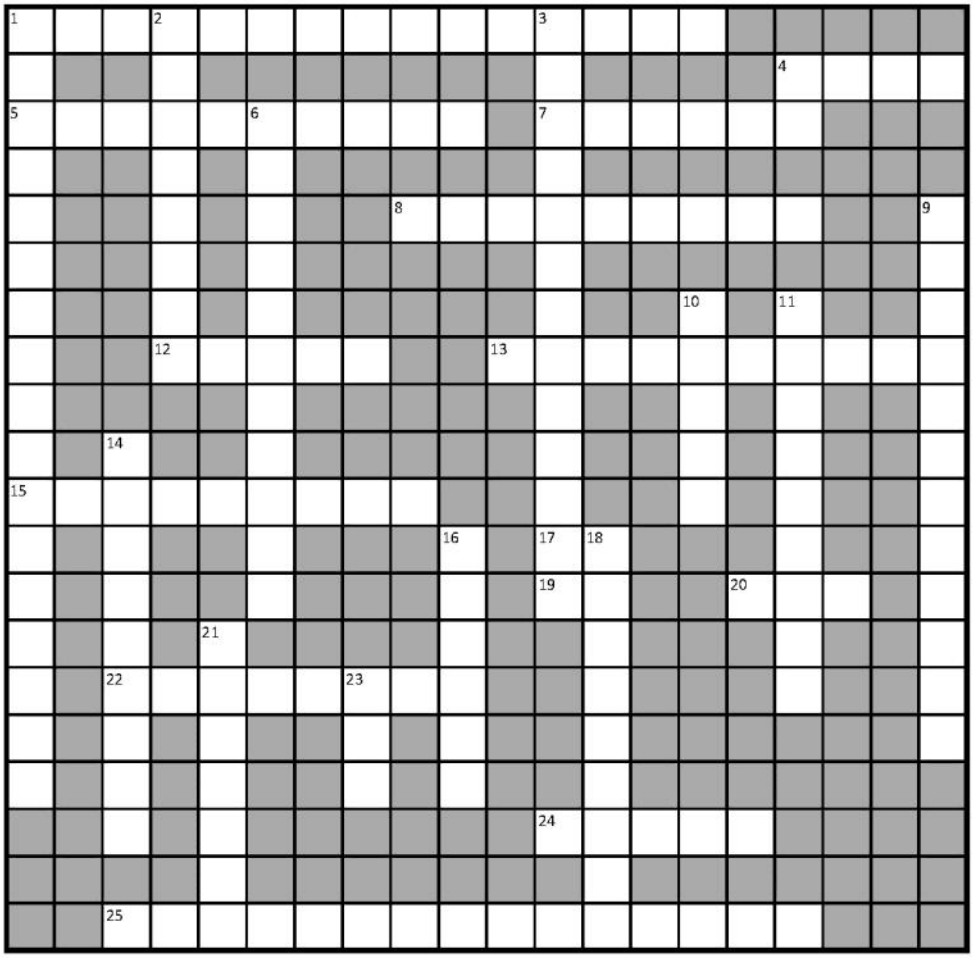
Central Michigan University will continue to approve applicants to take the FG Exam based on their educational credentials. However, from March 2023 on, the exam may be taken on the scheduled test date and time at a large number of different CBT sites administered by Prometric (including CMU).

More information about registering for the March 17, 2023 ASBOG Exam and locating a Prometric test center will be available in the next AIPG newsletter.

Member Input Sought

The Section Executive Committee is seeking input from members on a variety of topics. Do you have any suggestions regarding speakers/presentation topics that you would like to hear? What about field trips or other events? Some place you'd like to see us go, or something you think the membership would enjoy doing? Then make your voice heard; please send your suggestions to one of the members of the Executive Committee; any of the seven members would be glad to hear from you. AIPG is your organization. Please help keep it relevant and interesting for all by participating.

Geology Crossword #10



Across
1. No crocodiles here
4. Very dry climate
5. Prehistoric cockroach
7. Black, gassy shale
8. Common evaporite
12. Mid-Devonian Epoch
13. Not a submarine
15. Equivalent to Berea & Bedford
17. ___ and them
19. Paternal predecessor
20. Third state of matter
22. The Mackinac Br. caissons were built here
24. Nail polish color
25. Formed when halite beds dissolved

Down
1 Together in Motown
2. Magnesiun rich evaporite
3. A former consulting company
4. Has an atomic mass of 95
6. "Winged" fossil
9. Not a salad dressing
10. Of caves and sinkholes
11. A cherty limestone
14. Early Devonian Epoch
16. Quarry off M-32 near Alpena
18. The Sylvania
21. The only Devonian waterfall in MI
23. e.g. crude

*The solution to this geology crossword will be included in the next edition of *Geologically Speaking*.